PATENT APPLICATION

INTERCONNECTION SCHEME FOR HEAD ARMS OF DISK DRIVE ACTUATOR

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INTERCONNECTION SCHEME FOR HEAD ARMS OF DISK DRIVE ACTUATOR

Technical field

This invention relates to the electrical interconnection of the heads of a disk drive using the head arms of the disk drive voice coil actuator.

Background Art

Disk drives are an important data storage technology, which is based on several crucial components. These components include the interconnection between the read/write heads, which actually communicate with a disk surface containing the data storage medium, and the read/write interfaces of the disk drive. While there has been great progress in disk drives, there are problems which have yet to be solved.

Figure **1A** illustrates a typical prior art high capacity disk drive **10** including actuator arm **30** with voice coil **32**, actuator axis **40**, suspension or head arms **50-58** with slider/head unit **60** placed among the disks.

Figure **1B** illustrates a typical prior art high capacity disk drive **10** with actuator **20** including actuator arm **30** with voice coil **32**, actuator axis **40**, head arms **50-56** and slider/head units **60-66** with the disks removed.

Since the 1980's, high capacity disk drives **10** have used voice coil actuators **20-66** to position their read/write heads over specific tracks. The heads are mounted on head sliders **60-66**, which float a small distance off the disk drive surface when in operation. Often there is one head per head slider for a given disk drive surface. There are usually multiple heads in a single disk drive, but for economic reasons, usually only one voice coil actuator.

Voice coil actuators are further composed of a fixed magnet actuator **20** interacting with a time varying electromagnetic field induced by voice coil **32** to provide a lever action via actuator axis **40**. The lever action acts to move head arms **50-56** positioning head slider

units **60-66** over specific tracks with remarkable speed and accuracy. Actuator arms **30** are often considered to include voice coil **32**, actuator axis **40**, head arms **50-56** and head sliders **60-66**. Note that actuator arms **30** may have as few as a single head arm **50**. Note also that a single head arm **52** may connect with two head sliders **62** and **64**.

The evolution of disk drives stimulated the computer revolution. While contemporary actuator designs are essential to the progress to date, there remain problems limiting the reliability and capability of disk drives built with contemporary voice actuators. One problem has to do with the method of electrically interconnecting heads to the head interface electronics.

Figures **2A**, **2B**, **2C** and **2D** illustrate a prior art actuator arm from the top view, detailed portion of top view, side view and front views, respectively.

Figure **2A** illustrates a top view of a prior art actuator arm **30** showing head arm **50**, actuator axis **40**, and head slider **60** of Figure **1** with detail region **70** illustrated in Figure **2B**.

Figure **2B** illustrates a top view of detail region **70** of Figure **2A**.

Figure **2C** illustrates a side view of part of detail region **70** of Figure **2B** indicating the interconnections **74-80** via various head sliders as found in the prior art. Each of these labeled interconnections includes two pairs of differential signals. One differential signal pair interconnects a read head to a read interface of the disk drive. The other differential signal pair interconnects a write head to a disk drive write interface.

Figure **2D** illustrates a different perspective on Figure **2C**, illustrating that these signal interconnections **74** may be embodied as various forms of cables attached to a head arm, including flex and ribbon cables.

Figure **2E** illustrates an alternative prior art electrical interconnection scheme for **74-80** essentially parallel to head arm **50**. Figure **2E** is typical of prior art uses of flex circuitry to interconnect head sliders and disk read/write interfaces. Four individual traces are

used for the read differential signal pair (**R+**, **R-**) and the write differential signal pair (**W+**, **W-**).

Figure **2F** illustrates a typical signal strength situation between a write differential signal pair and a read differential signal pair.

All of the known prior art face similar circuit situations, leading to a common problem. The differential signal traces are situated at differing distances from the ground plane, which runs through the head arms. Additionally, the differential signal traces are often not parallel to each other within the pair. These two situations lead differing differential signal pairs to have impedance mismatches, creating significant crosstalk between them.

Crosstalk is a function of both the distance between traces D, and the distance from the ground plane H. Crosstalk is proportional to 1/(1 + (D/H)^2).

Most importantly, the write differential signal pairs induce crosstalk on the read signal pair. This added noise limits the frequency at which the heads can be sensed and controlled. It also limits the reliability of the disk drive as a whole, reducing its life expectancy. This reduction in life expectancy is a cumulative effect of this noise, heating while the disk drive is operating and cooling when the disk drive is turned off.

Summary of the invention

The invention includes head arms providing head slider electrical interconnection as two or more essentially coplanor, parallel trace pairs near a ground plane to a disk drive read and write interface. These parallel traces use the metallic body of the head arm as a ground plane, insuring that the neighboring pairs of parallel traces used for differential read and write interconnection have essentially matched impedance. This is done through the uniform distance between traces and the uniform height of the traces from the ground plane of the head arm, creating matched impedance line pairs and significantly reducing crosstalk.

The invention includes voice coil actuator arms comprised of at least one of such head arms providing electrical interconnection.

The voice coil actuator arms may further comprise a top head arm using a bottom face for interconnection, at least one interior head arm using both top and bottom face for interconnection and a bottom head arm using the top face for interconnection.

The method of manufacturing a voice coil actuator arm using a head arm containing parallel traces near a ground plane made from the metallic infrastructure of the head arm produces voice coil actuators with superior reliability, due to the matched impedance lines providing read/write head interconnection.

Such interconnection schemes are cost efficient to manufacture, providing matched impedance line pairs for each of the several read/write heads supported by the actuator arm assembly.

The manufacturing method further includes making these interconnections by at least one of the following: Bridge Flexible Cable (BFC), Flex On Suspension (FOS) and Trace Suspension Assembly (TSA).

The invention includes the disk drives made using these voice coil actuator arms. Providing matched impedance lines to read/write heads, reduces noise and improves disk drive reliability. Improved reliability supports increased disk drive life span. Reduced noise improves track density.

These and other advantages of the present invention will become apparent upon reading the following detailed descriptions and studying the various figures of the drawings.

Brief Description of the Drawings

Figure **1A** illustrates a typical high prior art capacity disk drive **10** including actuator arm **30** with voice coil **32**, actuator axis **40**, suspension or head arms **50-58** with slider/head unit **60** placed among the disks;

Figure **1B** illustrates a typical prior art high capacity disk drive **10** with actuator **20** including actuator arm **30** with voice coil **32**, actuator axis **40**, head arms **50-56** and slider/head units **60-66** with the disks removed;

Figure **2A** illustrates a top view of a prior art actuator arm **30** showing head arm **50**, actuator axis **40**, and head slider **60** of Figure **1** with detail region **70** illustrated in Figure **2B**;

Figure **2B** illustrates a top view of detail region **70** of Figure **2A**;

Figure **2C** illustrates a side view of part of detail region **70** of Figure **2B** indicating the interconnections **74-80** to various head sliders as found in the prior art, interconnections **74** and **76** may provide the differential read signals, interconnections **78** and **80** would then provide the differential write signals;

Figure **2D** illustrates a different perspective on Figure **2C**, illustrating that these signal interconnections **74** to **80** may be provided as strips for use in an automated reflow solder system;

Figure **2E** illustrates an alternative prior art electrical interconnection scheme for **74-80** essentially parallel to head arm **50**;

Figure **2F** illustrates a typical signal strength situation between a write differential signal pair and a read differential signal pair;

Figure **3A** illustrates a voice coil actuator containing a head arm **150** in accordance with the invention;

Figure **3B** illustrates a cross sectional view of three head arms **150**, **152** and **154** through line **A-B** of Figure **3A**; and

Figure **3C** provides a detail of head arm **150** showing a dielectric layer **190** separating traces **174-180** from the ground plane of head arm **150**.

INS A1

Detailed Description of the Invention

Figure **3A** illustrates a voice coil actuator containing a head arm **150** in accordance with the invention.

INS A2

Figure **3B** illustrates a cross sectional view of three head arms **150**, **152** and **154** through line **A-B** of Figure **3A**. Each head arm contains at least two differential signal pairs through traces **174**, **176**, **178** and **180**, which are coplanar, parallel and close to ground planes provided by the metallic infrastructure of each head arm. Note that head arm **152** also includes third and fourth differential signal pairs through traces **182-188**, again essentially coplanor, parallel and close to the ground plane of head arm **152**.

The head arms **150-154** provide head slider electrical interconnection as two or more essentially coplanar, parallel trace pairs **174**, **176**, **178** and **180** near a ground plane to a disk drive read and write interface. By using the metallic body of the head arm as a ground plane, these parallel trace pairs **174**, **176**, **178** and **180** insure that parallel trace pairs used for differential read and write interconnection have essentially matched impedance. This is done through the uniform distance between traces and the uniform height of the traces from the ground plane of the head arm, creating matched impedance line pairs and significantly reducing crosstalk.

Note that the invention includes voice coil actuators including at least one of such head arms **150**, **152**, and/or **154** providing electrical interconnection.

The voice coil actuators **30** may further comprise a top head arm **150** using a bottom face for interconnection, at least one interior head arm **152** using both top and bottom face for interconnection and a bottom head arm **154** using the top face for interconnection.

Figure **3C** provides a detail of head arm **150** showing a dielectric layer **190** separating traces **174-180** from the ground plane of head arm **150**. As one of skill in the art will recognize, there are a wide variety of material choices for the infrastructure of head arm **150**, dielectric layer **190** and traces **174-180**.

Note that the use of a predominantly copper alloy for at least the traces **174-180** may be preferred in certain applications. Use of a predominantly aluminum alloy infrastructure may be preferred for head arm **150**. Dielectric **190** may preferably be a polyimide material, often used in Flex on Suspension printed circuit production.

Note that an additional parallel, coplanar trace tied to ground may be placed between trace pairs to further minimize crosstalk.

The method of manufacturing includes making a voice coil actuator arm **30** using a head arm **150-154** containing parallel traces near a ground plane made from the metallic infrastructure of the head arm. This method produces voice coil actuator arms **30** with superior reliability, due to the matched impedance lines providing read/write head interconnection.

The method of manufacture includes, but is not limited to, the signal traces being part of a flex circuit manufacturing method. The manufacturing method further includes making these interconnections by at least one of the following: Bridge Flexible Cable (BFC), Flex On Suspension (FOS) and Trace Suspension Assembly (TSA).

Such interconnection schemes are cost efficient to manufacture, providing matched impedance line pairs for each of the several read/write heads supported by the actuator arm assembly.

The invention includes the disk drives **10** made using these voice coil actuator arms **30**. Providing matched impedance lines to read/write heads, reduces noise and improves disk drive reliability. Improved reliability supports increased disk drive life span. Reduced noise improves track density.

The preceding embodiments have been provided by way of example and are not meant to constrain the scope of the following claims.